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ASSOCIATIVE FACILITATION AND INTERFERENCE IN THE RECALL OF SENTENCES.

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LISTS OF HIGH ASSOCIATION AND LOW ASSOCIATION SENTENCES WERE PREPARED FROM CONTROLLED ASSOCIATION NORMS. AN INTRA-LIST INTERFERENCE CONDITION WAS CREATED FOR HIGH ASSOCIATION SENTENCES BY PAIRING THE NOUN PHRASE OF ONE SENTENCE WITH THE VERB PHRASE OF ANOTHER SENTENCE IN THE SAME LIST. A SIMILAR PROCEDURE WAS FOLLOWED WITH THE LOW ASSOCIATION SENTENCES. EACH OF THE FOUR EXPERIMENTAL LISTS WAS PRESENTED TO A DIFFERENT GROUP OF 24 UNDERGRADUATE STUDENTS AS A SENTENCE RECALL TASK. THE PERFORMANCE OF THE HIGH ASSOCIATION GROUPS WAS SUPERIOR TO THE PERFORMANCE OF THE LOW ASSOCIATION GROUPS, AND THE PERFORMANCE OF THE NONINTERFERENCE GROUPS WAS SUPERIOR TO THE PERFORMANCE OF THE INTERFERENCE GROUPS ON SEVERAL MEASURES OF RECALL. TRANSITIONAL ERROR PROBABILITIES WERE COMPUTED FOR THE BETWEEN-PHRASE AND THE WITHIN-PHRASE TRANSITIONS OF THE SENTENCES IN EACH OF THE LISTS, AND THE RESULTS OF THE ANALYSIS OF THESE DATA WERE CONSISTENT WITH THE NOTION THAT ASSOCIATIVELY-INTEGRATED SENTENCES ARE PROCESSED IN UNITS LARGER THAN THE PHRASE, WHILE LOW ASSOCIATION SENTENCES ARE PROCESSED IN PHRASE UNITS. THIS REPORT APPEARED IN "STUDIES IN LANGUAGE AND LANGUAGE BEHAVIOR, PROGRESS REPORT IV," 1967, PUBLISHED BY THE CENTER ON LANGUAGE AND LANGUAGE BEHAVIOR, UNIVERSITY OF MICHIGAN, 220 EAST HURON STREET, ANN ARBOR, MICHIGAN 48108. (AUTHOR/JD)

Associative Facilitation and Interference in the Recall of Sentences

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Lists of high association (HA) and low association (LA) sentences were prepared from controlled association norms. An intralist interference condition was created for HA sentences by pairing the noun phrase of one sentence with the verb phrase of another sentence in the same list. A similar procedure was followed with the LA sentences. Each of the four experimental lists was presented to a different group of 24 Ss as a sentence-recall task. The performance of the HA groups was superior to the performance of the LA groups, and the performance of the noninterference groups was superior to the performance of the interference groups on several measures of recall. Transitional error probabilities were computed for the between-phrase and the within-phrase transitions of the sentences in each of the lists, and the results of the analysis of these data were consistent with the notion that associatively-integrated sentences are processed in units larger than the phrase, while LA sentences are processed in phrase units.

When we process sentences in a verbal learning task our behavior is likely to be influenced by a variety of language habits that we bring to the situation, including some that are related to the structure of our language, that are the result of experiences common to members of a culture, and that are idiosyncratic. Of particular interest in the present study were the kinds of habits that are revealed by word-association norms. A second interest was to determine whether the way in which sentences are learned reveals anything about their linguistic structure.

In a recent study (Rosenberg, 1966b) of the role of associative habit in the recall of sentences, in which sentences of the form adjective-noun-verb-adverb were used, high association (HA) sentences were constructed by selecting the adjective, verb and adverb in each sentence from among the high-strength (frequent) responses to the noun, and low association (LA) sentences were constructed by selecting the adjective, verb and adverb from among the low-strength (infrequent) responses to the noun. Free association (FA) norms were used for this purpose. Recall of HA sentences was clearly superior to recall of LA sentences.

One of the difficulties with the preceding study is that, in the construction of the sentences, it was assumed that in manipulating associative habit we were

in part manipulating meaningfulness (sentence understanding). For this reason, most of the LA sentences were semantically anomalous. Associative habit, then, was seen to contribute to sentence understanding and thus to sentence generation during recall. Unfortunately, this view can no longer be taken seriously. Recent developments in linguistic theory (e.g., Chomsky, 1965) have made us aware of the fact that a language-user is capable of generating and understanding utterances that he has never heard or spoken before. All natural languages known to man appear to share this "creative aspect" in common. In the construction of sentences varying in associative strength, then, we should be concerned with the manipulation of the probability of co-occurrence of words, rather than meaningfulness. The important point to be made here is that the inferior recall of LA sentences in Rosenberg's (1966b) study could have been the result of semantic anomaly, rather than associative strength. In the present study, an attempt was made to avoid anomaly among the LA sentences.

In memorizing a sentence, the word constituents must be integrated into a whole. Pre-experimental associative constraints should facilitate such integration. This situation should also permit us to create an interference condition by pairing the noun phrase (NP) of one HA sentence with the verb phrase (VP) of another HA sentence in the same list. These HA interference (HAI) sentences should be more difficult to learn than the HA noninterference (HANI) sentences, but easier to learn than their LA counterparts, since phrase integration would still be facilitated by the strong associative constraints within phrases. Since associative constraints are already weak within LA sentences, there should be little difference in the recall of LAI sentences as compared with LANI sentences.

The independent variables in the present study were arranged in a 2 x 2 factorial design, with two levels of associative habit, HA and LA, and two levels of phrase relatedness, NI and "I". The sentences that were used in the study were prepared from recently-developed (Rosenberg, 1965) associative sentence norms. In the norm study, male and female Ss were asked to associate an adjective, a verb and an adverb to a noun embedded in a sentence frame.

Johnson (1965) has presented evidence to support the notion that in processing sentences words are recoded into phrase units. He employed a paired-associate learning task with sentences as response items. The probability of a transitional error (TE), i.e., the probability of going from a right to a

wrong response, was found to be greater between phrase boundaries than within phrase boundaries. The patterns of TE probabilities that were observed reflected the linguistic structure of the sentences, and Johnson proposed a "cognitive operations" theory to explain the findings. Other data presented in this article and the results of a subsequent study (Johnson, 1966) led Johnson to conclude that his results could not b accounted for in terms of differential intra- and inter-phrase associative constraints between the words in the sentences he used. According to Johnson (1966, p. 369),

One of the implications of the model is that if Ss use associations in generating sentences they are probably between the hypothetical decoding operations rather than the responses themselves. The implication was tested by establishment of an adjective-noun (A-N) and a noun-verb (N-V) association prior to learning sentences which incorporated these word pairs. The model suggests that the operations involved in generating the adjective and noun are adjacent, while those generating the noun and verb are not. Therefore, it was predicted that during the sentence learning the A-N transition should be facilitated by the prior association while the N-V transition should not. The results confirmed the hypothesis.

While I am generally sympathetic to Johnson's position, it is possible that laboratory-established associations (in the case of the N-V transition) do not have the strength of natural language associations. It is possible, in other words, that with a normative HA sentence, words may be recoded into units larger than the phrase. The result of such recoding would most likely be a reduction in the probability of a TE at the phrase boundary. This notion was tested in the present study by computing TE probabilities for the various experimental groups.

Method

Subjects. The Ss were 96 undergraduates who volunteered and were paid for their participation. They were assigned in rotation to the various conditions, without bias, as they appeared for the experiment. There were 24 Ss in each group. All conditions were represented simultaneously in a group-testing situation and the data were collected in four sessions. The number of Ss in the sessions varied from 12 to 30 and in the groups within each session the number varied from three to eight.

Materials. The experimental list in each group contained four sentences of the form article-adjective-noun-verb-adverb with the verb always in the past

tense. The sentences were constructed with the assistance of the associative sentence norms (Rosenberg, 1965) mentioned earlier. In each of the HA sentences, the adjective, verb and adverb were the most frequently occurring responses (male and female norms combined) in the norms to the subject-noun (e.g., The old king ruled wisely). The LA sentences (e.g., The poor king dined gravely) contained the same nouns as the HA sentences, but the adjectives, verbs and adverbs were all selected from the bottom of their respective associative response hierarchies (a frequency of one or two out of a possible 288 responses). The adjectives, nouns and verbs in lists HA and LA were all A or AA words in the Thorndike-Lorge (1944) general count. The average T-L frequency of the adverbs in the HA list was 24, and in the LA list 21. The HA and LA words were matched as closely as possible on length. In addition, the sentences were selected so as to avoid intralist associative interference within the basic HA and LA lists.

Procedure. The data were collected in a classroom in a group-testing situation. The exposure interval for each sentence was 5 sec. Each study trial was followed immediately by a 1 min. written recall test, and the interval between the end of the recall test and beginning of the next study trial was 5 sec. The Ss were given detailed instructions in the use of the booklets. They were told that their task was to try to learn as many of the sentences as they could on each study trial. In addition, they were told that the order of sentences within a list was not important. However, it was emphasized that the order of words within each sentence was important. For the recall task, they were urged to write down as much of each sentence as they could remember, and to try to guess at items they could not remember. Any position within a sentence for which a word could not be supplied was to be filled in with a dash. The signal to turn each page was delivered verbally by E to the beat of a metronome.

The sentences were printed in booklets, one sentence to a page, and each booklet contained four repetitions of a list. The page that followed the last item in a list was blank and lined and was used for the written recall test. Four orders of each list were constructed so that the order of sentences from trial to trial could vary, and each order occurred equally often on each of the four trials within each condition. Exposure intervals were timed with a metronome and the retention tests with a stopwatch.

The lists that we have just discussed constituted the HANI and LANI conditions. The interference conditions were created by simply splitting the sentences in these lists at their phrase boundaries and then pairing the NP from one sentence with the VP from another sentence in the same list. The pairing was done at random, and two different pairings were made in each list to control for possible effects of the particular pairing.

Results

Table 1 contains the means and SD's for the total number of complete sentences recalled correctly (TS); total words recalled correctly, without regard

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Insert Table 1 about here

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for location on the recall sheets (TW); and the proportion of TW that were recalled in complete sentences (PWS). The third score was a measure of the relative tendency to recall words in sentences. Each S's score on these measures represented his total performance over the four trials. It can be seen in Table 1 that on all of these measures of recall, the HA groups were superior to the LA groups and the NI groups were superior to the "I" groups.

A 2 x 2 factorial analysis of variance was carried out on each of the measures summarized in Table 1, and, in all instances, the effects of association and interference were highly significant (df = 1,92, $p < .001$). None of the interactions, however, approached significance. The Fs for association and interference for TS were, respectively, 22.69 and 20.80; for TW they were 43.42 and 13.26; and for PWS they were 9.33 and 19.67.

The recall protocols were then scored for the total number of words recalled correctly in each sentence position. Each sentence position is occupied of course, by a different form class. The results of this scoring have been summarized in Table 2. With the exception of the difference between Groups LANI

Insert Table 2 about here

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and LAI in the recall of nouns, which was very small, the trends revealed in Table 2 are identical to the trends revealed in Table 1. With respect to the effect of sentence position, the sentence position function appears to be flatter in Group HANI than in the other groups. A Lindquist (1953) Type III analysis of variance on these measures resulted in an F (1,92) of 43.67 for

association (p <.001), an F (1,92) of 15.28 for interference (p < .001), and F (3,276) of 65.54 for sentence position (p < .001), an F (3,276) of 10.92 for the interaction between association and sentence position (p < .001), and an F (3,276) of 3.01 for the interaction between interference and sentence position (p < .05). The interaction between association and interference, and the triple interaction were both non-significant.

It appears, then, that the effects of association and interference vary as a function of the position (or form class, since the two are perfectly correlated in the present sentences) of a word in the sentences. In Group HANI, significantly more nouns were recalled than adjectives (p < .01) and adverbs (p < .01); significantly more verbs were recalled than adjectives (p < .05) and adverbs (p <.05); but none of the other pairwise differences were significant. In Groups LANI and LAI, nouns were superior to each of the other form classes (p < .01), but none of the other differences were significant. In Group HAI, the nouns were also superior to each of the other form classes, but, in addition, the verbs were superior to the adjectives (p < .01). A procedure suggested by Lindquist (1953) was used for these within-comparisons. The error term was based upon the data for all of the groups, but the df's were based upon the number of observations in a given group.

Separate analyses of variance (2 x 2) were carried out for each of the sentence positions, and the results were the same as the results for TS, TW and PWS in all instances. Thus, the significant interactions that were found between sentence position and the other variables were the result of group differences in the serial position function.

The means for the number of NP's and VP's recalled correctly by each group can be found in Table 3. Again, the HA conditions were superior to the

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Insert Table 3 about here

LA conditions, and the NI conditions were superior to the "I" conditions. In addition, more NP's were recalled than VP's in all groups except Group HANI, where the difference between phrase types was virtually zero. An F (1,92) of 31.00, p < .001, was found for association, an F (1,92) of 16.82, p < .001, for interference, an F (1,92) of 16.92, p < .001, for phrase type, and an F (1,92) of 11.79, p < .001, for the interaction between association and phrase type. None of the other interactions were significant. The

significant effect of phrase type indicates that there was a tendency for NP's to be recalled more frequently than VP's. However, since there was a significant interaction between association and phrase type, the difference between the NP's and the VP's was evaluated for each group. Significantly more NP's were recalled than VP's in groups LANI and LAI ($p < .01$), but the effect of phrase type was non-significant in Groups HAN~ and HAI. Thus, the presence of strong associative constraints within phrases tends to flatten out the sentence position function for phrases.

When associative constraints between words within the same sentence are as weak as associative constraints between words in different sentences, in the same list (as is the case with the LA sentences of the present study), intrusion errors are likely to take place, i.e., words from one sentence are likely to be recalled in the context of words from another sentence. And, of course, an HA interference condition should also increase the tendency to make intrustion errors. The mean per cent intrustion errors (intrusion errors divided by total errors) was 9.38 in Group HANI, 13.88 in Group LANI, 30.58 in Group HAI and 21.00 in Group LAI. A chi-square ($df = 1$) median test was used to evaluate these data. The only chi-square (corrected for continuity) to reach significance was for the comparison between Groups HANI and HAI (9.10, $p < .01$). The value of chi-square for the difference between Groups LANI and LAI (3.01) approached, but did not, reach significance at the .05 level. Thus, the hypothesis in question was only confirmed in the case of the HAI condition.

The TE probabilities for the adjective-noun (A-N), noun-verb (N-V) and verb-adverb (V-Av) transitions can be found in Table 4. These figures are

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Insert Table 4 about here

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based upon the data summed over sentences, trials and Ss, and they were computed by dividing the frequency with which a response following a correct response was wrong (a wrong word or no word at all) by the frequency with which the preceeding response was right. If there was a tendency to recode the words in the sentences into phrase units, then the probability of a TE should have been greatest for the N-V transition. It is to be noted that this was the case for all of the groups, except Group HANI. In this group, the TE probability was highest for the V-Av transition. The V-Av transition appears to have been a "softer" transition than the A-N transition in all of the groups. To

determine whether the three TE probabilities were significantly different from one another in the various groups, Friedman two-way analyses of variance were computed. The Xr^2 (2) for Group HANI was 8.16, $p < .02$, for Group LANI it was 20.97, $p < .001$, for Group HAI it was 10.68, $p < .01$, and for Group LAI it was 22.55, $p < .001$. The transition variable, then, was a significant source of variance in all groups.

To determine whether the N-V transition was more difficult than the A-N and the V-Av transitions, Wilcoxon matched-pairs signed-ranks tests were performed. In Group HANI, the N-V transition differed significantly from the V-Av transition ($p < .02$), but not from the A-N transition. Clearly, the TE probability for the N-V transition was not higher than the TE probability for the A-N and the V-Av transition in Group HANI, as would have been predicted from the phrase structure of the sentences. In Group LANI, the N-V transition differed significantly (in the direction predicted from phrase structure) from the A-N transition ($p < .01$) and the V-Av transition ($p < .05$). In Group HAI, where the N-V transition represents not only a phrase break but an association break as well, the N-V transition was significantly higher than the A-N transition ($p < .01$); but it was not significantly higher than the V-Av transition. Thus, there is only partial confirmation for the lingistic hypothesis in Group HAI. The results for Group LAI on these comparisons were identical to the results for Group LANI. It appears, then, that the pattern of TE probabilities predicted from the phrase structure of the sentences used in the present study was confirmed only for LA sentences.

A comparison of the A-N transition with the V-Av transition in each of the groups revealed that in all instances, the probability of a TE within the VP was significantly greater ($p < .01$) than the probability of a TE within the NP. These results may reflect the fact that the adverb in each of the present sentences modifies the rest of the sentence. The V-Av transition, therefore, may not represent a within-phrase transition but a transition between a VP and an optional major constituent.

Group comparisons were made on the N-V transition using the normal approximation to the Mann-Whitney U Test. The Group HANI transition was found to be significantly lower than the transition in each of the other groups ($p < .001$), the Group LANI transition was found to be significantly lower than the Group LAI transition ($p < .02$), and the Group HAI transition was found to be significantly lower than the Group LAI transition ($p < .02$). What is important here is that

the HA TE probabilities on the N-V transition were significantly lower than the LA TE probabilities, and that the NI TE probabilities were significantly lower than the "I" TE probabilities. An examination of Table 4 will show that the A-N and V-Av transitions were not as sensitive to differences in associative constraints as was the N-V transition. This is especially true for the A-N transition. None of the HA LA or NI "I" comparisons for these transitions produced a significant Z.

A TE probability was also computed for the NP-VP transition in each group. The question that was asked was: What is the probability of failing to recall the VP correctly, if the NP was recalled correctly? This value, for Groups HANI, LANI, HAI, and LAI, respectively, was .08, .16, .17, and .30. Each of the HA groups was significantly lower than its LA counterparts ($p < .01$), and each of the NI groups was significantly lower than its "I" counterparts ($p < .01$). The normal approximation to the Mann-Whitney U Test was used to evaluate these differences. These results suggest that phrase integration was facilitated by both within-phrase and between-phrase associative constraints.

Discussion

Since an attempt was made in the present study to construct LANI sentences that would not be semantically anomalous, the superior recall of HANI sentences, words and phrases can be attributed to the facilitating effects of associative constraint. Further evidence of the effectiveness of associative constraint in sentence learning can be found in the results of Group HAI. The results for Group HAI (as contrasted with Group LAI) are interesting in that they indicate that strong associative constraint within phrases can overcome the debilitating effect of a within-list interference condition upon the recall of complete sentences.

The observation that LANI sentences were easier to learn than LAI sentences was not consistent with expectations. One possible explanation for these findings is that the pairing of phrases to produce the LAI sentences may have resulted in some sentences that were anomalous. An examination of the LAI sentences revealed that each of the two pairings did contain a sentence which was clearly anomalous. The sentences in question were, The dark river watched nicely and The dark river dined gravely. As a check upon the validity of this explanation, the results for these sentences and their LANI counterparts were

subtracted from the sentence-recall scores. However, even with the data for the anomalous sentences deleted, Group LANI was superior to Group LAI. The only other explanation that seems reasonable at this time is that the associative constraints within the LANI sentences, even though they were weak, may have been stronger than the associative constraints within the LAI sentences.

The strong tendency toward overt intrusion errors in Group HAI, as contrasted with Group HANI, was consistent with expectations. However, the finding that the HA groups did not differ from their LA counterparts in the percentage of the total number of errors made that were intrusion, is not consistent with expectations, and, in addition, is not consistent with the results of the earlier (Rosenberg, 1966b) study. One possible explanation for the discrepancy is that the earlier results reflected the effect of semantic anomaly and not associative strength. This would mean that the hypothesis that a list of meaningful LA sentences is likely to produce proportionately more intrusion errors in recall than a list of meaningful HA sentences is untenable.

Perhaps the most interesting findings of the present study are those that relate to the TE probabilities. While the results (i.e., the TE patterns) for the LA sentences are supportive of Johnson's (1965; 1966) findings, and the results for the HAI sentences are partially supportive of Johnson's findings, the results for the HANI sentences are not. In addition, the probability of a TE in going from the noun to the verb and the probability of a TE in going from the NP to the VP were found to be related to the normative strength of the N-V association. Also, in contrast with Johnson's (1966) findings the results for the A-N and V-Av transitions indicate that Ss are more likely to use between-phrase associative constraints than within-phrase associative constraints. What is suggested by these results is that normative associative constraints are more likely to influence sentence processing at phrase boundaries than within phrases. Why this should be the case is not clear at present.

What is also interesting is that the probability of a TE at the N-V transition for the HAI sentences was significantly lower than the probability of a TE at the same transition for the LAI sentences. Supposedly, associative constraints were weak at the phrase boundaries in both of these lists. It is possible, however, that the presence of strong associative constraints within the phrases of the HAI sentences facilitated the process of NP-VP integration. The TE data for the NP-VP transition appear to support this notion.

It is possible, then, that sentences of the HANI type--associatively integrated sentences--are processed in units larger than the phrase (perhaps, in some cases, the unit is the whole sentence), while sentences of the LANI type are processed according to their phrase structure. Whatever is responsible for the discrepancies between the results of Johnson's studies and the results of the present study, it is clear that the relationship between sentence processing and linguistic structure is more complex than Johnson's work suggests.

As a final point, it should be mentioned that the results of the present study have served to demonstrate the usefulness of controlled-association norms (Rosenberg, 1965) in the construction of sentences varying in associative strength. The ease with which these norms were collected led recently to the development of a similar set of norms for the simple declarative sentence type (Rosenberg, 1966a).

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Table 1

Means and Standard Deviations for

Various Measures of Recall

Group	Measure		
	TS	TW	PWS
HANI			
Mean	12.92	59.42	.87
SD	1.61	3.16	.07
LANI			
Mean	9.92	50.33	.77
SD	3.01	6.23	.17
HAI			
Mean	10.04	54.04	.72
SD	3.85	7.41	.22
LAI			
Mean	7.21	46.54	.60
SD	3.08	6.95	.20

Table 2

Mean Number of Adjectives, Nouns, Verbs

and Adverbs Recalled Correctly

Group	Sentence Position			
	Adj.	Noun	Verb	Adv.
HANI	14.21	15.67	15.21	14.33
LANI	12.25	14.38	12.00	11.92
HAI	12.38	14.83	13.71	12.96
LAI	11.04	14.12	10.88	10.38

Table 3

Mean Number of Noun Phrases and

Verb Phrases Recalled Correctly

Group	Phrase	
	NP	VP
HANI	14.04	14.08
LANI	11.79	10.62
HAI	12.04	11.75
LAI	10.46	8.58

Table 4

Transitional Error Probabilities for

the A-N, N-V, and V-Av Transitions

Group	Transition		
	A-N	N-V	V-Av
HANI	.01	.03	.06
LANI	.02	.18	.09
HAI	.03	.16	.13
LAI	.04	.28	.18